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Development and characterization of shape-controlled porous-carbon by flash heating of wood biomass

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The utilization of carbonized wood biomass has recently received fresh impetus owing to the vast amount of waste wood that has to be recycled without posing an environmental hazard. In particular, the use of carbonized wood biomass as a source of advanced carbon materials is been gaining considerable attention because of its high porosity and surface area. However, shape-controllability and pore distributions of porous carbon materials are also very important factors that determine its practical utility in industrial production [1,2]. Wood biomass maintains the original cell structure after carbonization, and its macro-textural cannot be changed easily. In the case of conventional heating, wood is converted into carbon by a series of chemical reactions such as dehydration, depolymerization [3]. On the other hand, flash heating means very rapid heating treatment for raw materials and the heating rate is defined 10-1000 °C /sec. The mechanism of thermal conversion is not the same for conventional or slow heating and flash heating. Flash heating of wood biomass promotes the depolymerization of starting materials in carbonization, e.g. fragmentation leading to a large quantity of volatiles evolving during the process [3].

The porosity determines the ability of fluid passage and treatment on porous carbons [4], and the surface area determines the reactivity and capacity in each application. Generally, finer carbon-particle sizes are effective for increasing the surface area. However, such fineness brings about a decrease in the porosity between the particles. Furthermore, shape control of porous carbons requires many additional processes such as granulation, heat treatment, and compression. Recently, shape-controlled porous carbon (SC-PC) materials and their simple and inexpensive preparation methods have been applied in advanced technological fields such as catalyst filters [5], fuel cell batteries [6], and functional porous metals [7].

Firstly, flash heating has been applied for the liquefaction of wood biomass [3] and a semi-closed graphite-reactor has been used to realize unique macro-texture and shape controllability in this study. Flash heating very effectively changed the original micro-texture of the sawdust into a texture similar to that of melted carbon [8], and it was also reported that the shapes of the carbon products after flash heating corresponded to the interior shape of the semi-closed graphite-reactor [9]. The shape-controlled porous-carbon synthesized by flash heating in the semi-closed graphite-reactor showed a porosity of over 80%, which originated from the macro-pores (size: 5–50 μm) between cross-linked carbon beams. Moreover, such three-dimensional macro-texture also enables shape control of porous carbons without binders or frames and provides versatility in manufacture, design, and finishing (Fig. 1). However, the BET surface area of the SC-PC was found to be 370 m^2/g, which is half the surface area of conventional activated carbon powder [10].

The surface area of carbon materials increases with oxidation on the surface of a precursor; this process is called activation. Activation has been applied widely in industry because the oxidation facilitates the development of micro-pores and meso-pores. Then, secondary, the SC-PC prepared by flash heating of sawdust in a semi-closed graphite-reactor system was improved by a subsequent heat treatment. This new porous carbon products combined a high surface area of 670m^2/g with high porosity of over 80%. Subsequent low-temperature heat treatment (380 °C) was effective in increasing the surface area while maintaining the original three-dimensional microtexture and porosity. In addition, the heat treatment produced meso-pores of between 5 nm and 50 nm and micro-pores of less than 2 nm on the surface of the cross-linked carbon beams that formed the shape of the carbon material (Fig. 2). Moreover, macro-pores of between 5 μm and 50 μm were observed between the crosslinked carbon beams. Therefore, it was confirmed that shape-controlled multi-porous carbon (SC-MPC) contained micro-, meso-, and macro-pores in its microtexture while retaining its shape and strength [10].

Finally, a catalyst filter that deposited Pd-nano-particles homogeneously was synthesized by using SC-MPC as a novel catalyst support and by employing an electroless-plating procedure. In addition, SC-Ni was obtained by electrically plating nickel on SC-PC and subsequently removing the SC-PC as a carbon template. The surfaces of SC-MPC-Pd and the SC-PNi were analyzed and the modifications for application to advanced materials were determined by using electrical microscopes, porosimeters, XRD, and XPS. The Pd particles had sizes smaller than 5 nm and they were distributed homogeneously on the amorphous

carbon surface and reduced to metallic Pd particles in SC-MPC (Fig. 3). SC-PNi was obtained from cross-linked nickel tubes and its chemical composition mainly showed metallic nickel (Fig. 4) [10]. These syntheses can be tailored easily to produce other catalyst filters containing nano-particles of various noble metals, and porous metals such as Pt, Au, Ag, Cu, and Pd. Thus, SC-MPC has potential for wide utilization in various industrial fields such as environmental cleaning, electronic devices, and enzyme containers.

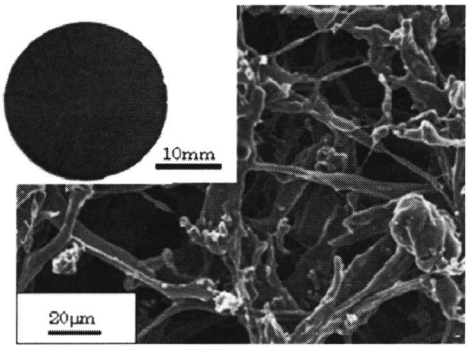

Fig. 1. Appearance and microtexture of coin shaped SC-PC prepared by flash heating and semi-closed reactor system.

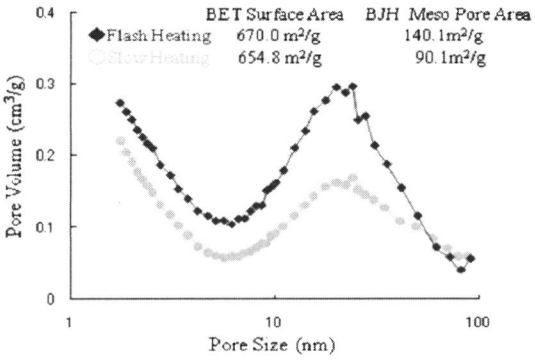

Fig. 2. dV/dlogD meso-pore volume distribution of the SC-MPC and activated slow heating sample.

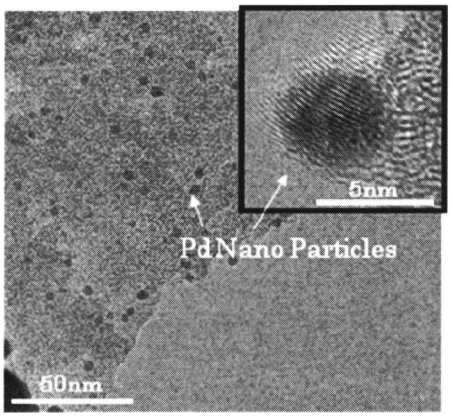

Fig. 3.The distribution of Pd and high resolution image of the Pd nano particle on the amorphous carbon surface observed by TEM.

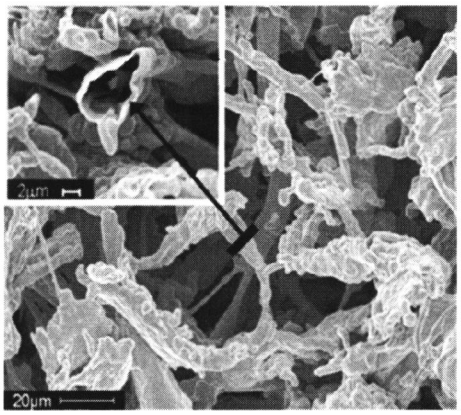

Fig. 4. The macro-texture of the surface and the cross-section on the cross-linked nickel tubes observed by SEM.

REFERENCES

[1] Rios R. V. R. A., Martinez-Escandell M., Molina-Sabio M., and Rodriguez-Reinoso F. Carbon, 2006, 44, 1448-1454.
[2] Calvo M., Garcia R., Arenillas A., Suarez I., and Moinelo S. R., Fuel, 2005, 84, 2184-2189.
[3] Graham R. G., Bergougnou M. A., and Overend R. P., J. Anal. Appl. Pyrol., 1984, 9, 95-135.
[4] Brasquest C. and Cloirec P. L., Carbon, 1997, 35, 1307-1313.
[5] Auer E., Freund A., Pietsch J. and Tacke T., Appl. Catal., 1998, A173, 259-271.
[6] Moriguch I., Nakahara F., Furukawa H., Yamada H., and Kudo T. Electrochem. Solid-State Lett. 2004, 7, A221-223.
[7] Banhart J. Manufacture, Prog. Mater. Sci. 2001; 46:559–632.
[8] Kurosaki, F. Ishimaru, K., Hata, T., Bronsveld, P., Kobayashi E. and Imamura Y., Carbon, 2003, 41, 3057-3062.
[9] Kurosaki F., Koyanaka H., Hata T. and Imamura Y., Carbon, 2007, 45, 671-673.
[10] Kurosaki F., Koyanaka H., Tsujimoto M. and Imamura Y., Carbon, 2008, 46, 850-857.